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UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
Water Resources Division

RECONNAISSANCE INVESTIGATION OF GROUND-WATER SUPPLY FOR DORA BELLE CAMPGROUND, SHAVER LAKE, CALIFORNIA

By

G. H. Davis

Prepared at the request of the
Department of Agriculture,
Forest Service

OPEN-FILE REPORT

Sacramento, California
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CONTENTS

ILLUSTRATIONS

TABLE

1/ Figure 1 at end of report.

~~MEMORANDUM REPORT ON~~ RECONNAISSANCE INVESTIGATION

OF GROUND-WATER SUPPLY FOR

DORA BELLE CAMPGROUND, SHAVER LAKE, CALIFORNIA

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Purpose and Scope

At the request of the United States Forest Service, the Ground Water Branch of the United States Geological Survey made a reconnaissance of the geologic features and water resources of the Dora Belle Campground in Sierra National Forest on the shore of Shaver Lake, Fresno County, California.

Basically, the water-supply problem at Dora Belle Campground is that the present supply obtained from a spring is not adequate to meet the present summer demand and is of poor quality. Plans call for a considerable increase in camping facilities. Thus, it is imperative that the present supply be augmented or, preferably, be replaced entirely. The Forest Service estimated the future peak demand to be about 25,000 gallons per day.

On October 28, 1957, the writer examined the area in the company of C. H. Fankboner, Assistant Forest Engineer, Sierra National Forest, and Ben Dix, Construction and Maintenance Foreman, Pine Ridge District.

Field work, done on October 28th and 29th, consisted of a brief geologic reconnaissance to determine the rock types and geologic structure, and a hydrologic reconnaissance consisting of a partial inventory of water wells and springs in the vicinity of the campground. A spring box near the western edge of Ball Diamond Meadow was pumped out with a Forest Service pump truck to determine its rate of recovery and potential production.

Topography and Climate

Dora Belle Campground is on the southwest shore of Shaver Lake, Fresno County, California, about ½ mile northeast of the village of Shaver Lake. The property presently includes the 40 acres of the SW¼SW¼ sec. 25, T. 9 S., R. 24 E., MDB&M, but an agreement is being negotiated with the Southern California Edison Co. to acquire considerable additional acreage in SE¼ sec. 26, in the same township (fig. 1).

The area is steep and rocky; local relief in the campground is on the order of 200 feet. To the northwest, Mount Stevenson rises 1,030 feet in about ¼ mile to a crest altitude of 6,404 feet. The area of the campground and its proposed extension drains to Shaver Lake through a small gully that cuts through the center of the campground. Most of the developed area of the village of Shaver Lake drains westerly to Musick Creek, although a few homes are on the lake side of the divide and thus are a potential source of contamination to the water supply of the campground.

Precipitation, most of which falls as snow in the months of December through March, averages about 30 inches per year (Calif. State Water Res. Board, 1951, pl. 3). Much of the precipitation is retained in storage in the rocks and soil throughout the dry season, as is evidenced by perennial springs and seeps at several localities in the vicinity of the campground.

Shaver Lake is formed by a dam across Stevenson Creek about 2 miles north of Dora Belle Campground. Originally built in 1892 to supply irrigation water and to deliver lumber by means of flumes and canals to the Clovis area, on the floor of the San Joaquin Valley, the lake is now one of several reservoirs in the Southern California Edison Company's Big Creek-San Joaquin River power development. It is raised and lowered in accordance with the company's power-generation schedule. Consequently, the level fluctuates rapidly over short periods, although generally the lake is virtually full in early summer and reaches its lowest level in autumn. The spillway level of Shaver Lake is 5,370 feet above sea level; at that level the maximum depth is about 190 feet. The present dam was built in 1927 by the Southern California Edison Co. Maximum storage in the lake is 135,000 acre-feet.

Acknowledgments

The assistance of C. H. Fankboner and Ben Dix, both of the U. S. Forest Service, who showed the writer around the campground area and pointed out many of the problems, is gratefully acknowledged. In addition, Charles Meyers, Douglas Young, Paul Ullum, and Charles Eckert, all of Shaver Lake, supplied information on depths and yields of wells.

Water-Bearing Characteristics of the Rocks

The entire Shaver Lake area is underlain by granitic rock described by Krauskopf (1953) as a hornblende-biotite granodiorite. Typically, the rock contains 20 to 30 percent quartz, plagioclase in excess of orthoclase, and both hornblende and biotite. In the vicinity of Dora Belle Campground the granodiorite is characterized by the presence of small, dark, elongate inclusions of a finer-grained igneous rock that locally contains prominent feldspar phenocrysts. The inclusions are oriented with their long axes in the plane of the platy foliation or flow structure. They range in length from a few inches to about 1 foot; the length generally is two to three times the width. In most of the area the inclusions have a fairly random, uniform distribution, but locally they occur in minnow-like swarms, suggesting that larger bodies of the darker rock were being assimilated by the granodiorite at the time of crystallization.

The foliation defined by orientation of mineral grains and inclusions is the most conspicuous internal structure of the granodiorite. However, a far more important structural control of the water-bearing character and topography of the terrane are the joints or well-defined cracks in the granodiorite that divide it into blocks. Two sets of vertical joints are well developed, the most prominent of which strikes about N. 20° W., the other about N. 65° E. (fig. 1). Joints striking in other directions are developed locally but do not show a consistent pattern. Where the vertical joints are widely spaced, exfoliation joints divide the rock into flat sheets or lenticular slabs that are roughly parallel to the ground surface.

Spacing of most of the joints ranges from 5 to 20 feet. Weathering is controlled largely by the joints, and rounded residual boulders are prominent in areas where the vertical joints are evenly spaced and equally well developed. Erosion proceeds most rapidly in jointed rock where the weathering is rapid. Accordingly, the topography is controlled by the direction of jointing. This is especially true along the western shore of Shaver Lake, where parallel ridges and valleys have developed along the N.20° W.aligment of the major joint system. At high water the valleys representing the closely jointed rock are occupied by arms of the lake. The ridges are underlain by more massive rock in which the vertical joints are widely spaced.

The rocks of the Shaver Lake area may be divided on the basis of water-bearing character into three principal classes: (1) fresh or slightly weathered granodiorite, (2) talus at the base of Mount Stevenson, and (3) residuum (popularly termed "decomposed granite").

Unlike sedimentary rocks in which nearly all the water is contained in the pores between the rock or mineral fragments, most if not all the water in fresh granitic rock is in open joints and other fractures. Even in heavily fractured or closely jointed crystalline rock, the total volume occupied by water is much less than in uncemerted sediments. Unless the joints and other fractures extend to considerable depth below the water table and are interconnected over a large area the total amount of water available is much less than to a well in alluvial deposits.

If the fractures are not open or are widely spaced, yields of water from fresh rock will be correspondingly small.

Talus is made up of angular blocks of granodiorite which have been broken from the parent mass by mechanical weathering and have fallen down steep mountain sides or have been carried downslope in landslides. The large, loose, angular rock fragments provide an excellent intake area for water, which moves readily downslope toward points of discharge at lower altitude. The lower slopes of Mount Stevenson to the west of Ball Diamond Meadow are littered with angular talus blocks. It appears that the talus is the source of water for the belt of springs along the western margin of the meadow (fig. 1).

Residuum, the chief source of domestic water, at the village of Shaver Lake, is formed by weathering in place of granodiorite. Factors that control the occurrence of this weathered rock at Shaver Lake are jointing and topographic position. Jointing determines the location of the weathering and topographic position determines whether the residuum will be preserved from erosion. Residuum may range in character from only slightly altered granodiorite to completely decomposed rock consisting of quartz grains in a matrix of clay. However, in the Shaver Lake area both weathering and erosion proceed at a rapid rate; hence, there is little thoroughly decomposed rock. Most of the residuum is a sandy material containing abundant feldspar crystals.

The residuum grades sharply into the fresh rock, especially where the joints are widely spaced. Fairly fresh residual boulders are enclosed in the residuum. Locally they are very large, up to 20 to 30 feet in width, but for the most part they are smaller. The thickness and character of the residuum are extremely variable. Wells within a few feet of large boulders have penetrated 50 feet or more of residuum without encountering fresh rock. Nearly all the domestic water supply of the town of Shaver Lake is obtained from wells tapping the residuum and, where favorably located, shallow wells have been reported to yield several hundred gph (gallons per hour).

Source and Movement of Ground Water

The source of ground water in the Shaver Lake area is the precipitation, which falls chiefly as snow in the months of December through March. As the snow melts, much of the water percolates through the soil into the underlying rock material. This ground water moves in the direction of the slope of the water table from the intake areas at high elevation to points of discharge such as wells, springs at the bases of slopes, low-lying areas of soggy ground, and ~~to~~ Shaver Lake itself. Wherever the water table is intersected by the land surface, discharge occurs. Barriers to ground-water movement, such as bodies of massive, unfractured granodiorite, locally cause the ground water to rise to the land surface and flow over the barrier ~~as~~ to the land surface ~~flow~~. Such a barrier is the ridge of massive granodiorite that forms the eastern limit of Ball Diamond Meadow (fig. 1). Ground water rising along this barrier is reported to sustain a small surface flow even during dry years.

Yield of Wells and Springs

Wells tapping residuum are the chief source of domestic water in the Shaver Lake area. Many homes in the village have individual wells, although many others are served by cooperative water enterprises or public utilities. Wells drilled in residuum generally yield sufficient water for a single home, but water systems that serve many customers require a large sustained yield. Table 1 presents records of some of the larger wells in the village. Yields range from 80 gph from well 9/24-35A1,[1] considered unsuccessful by the owner, to as much as 1,600 gph from well 9/24-35R1. It is probably significant that wells 35R1 and 35J1, the two most productive wells canvassed, also penetrate the greatest thicknesses of residuum above hard granodiorite. Most of the well owners report that water levels and productivity of wells decline markedly during late summer, suggesting that the available ground-water storage is rapidly depleted during the summer heavy-use period.

Springs have had only limited use for water supply, probably because most are in areas unfavorable for residential development. The spring at Dora Belle Campground, 9/24-25N1, is the only one in the area used extensively at present. It yields about 100 gph, which is inadequate for camp demands. Consequently, many campers obtain water for cooking and drinking at business places in the town. Forest Service officials report that the yield of the spring declines noticeably in late summer.

1/ For a description of the well-numbering system see p. 16.

The other two springs, 9/24-26K1 and26K2, canvassed by the writer, formerly supplied a long-abandoned sawmill at the foot of Mount Stevenson. No records are available on past performance of these springs which date back about 50 years. On October 29, a Forest Service pumper with a 7-hp motor was used to pump out spring 9/24-26K1. Because of clogging of the pump intake by leaves and pine needles, it was impossible to keep an accurate record of the discharge of the pump, but approximately 260 cubic feet or almost 2,000 gallons was discharged in about 2 hours. Measurements of recovery were made at intervals for about 5½ hours. During the first 1½ hours, the spring box filled at a rate of about 75 gph. During the next 2½ hours, it filled at about 55 gph, and during the last 1½ hours, at about 43 gph. The average recovery for the whole 5½-hour period was about 55 gph.

In addition to the springs listed in table 1, several natural seeps are shown on figure 1. These are for the most part along the west edge of Ball Diamond Meadow at the foot of Mount Stevenson. Here ground water moving through talus down the face of Mount Stevenson, rises to land surface owing to relatively low transmissibility of the deposits beneath Ball Diamond Meadow. Water also issues at land surface at the east edge of the meadow where a ridge of massive granodiorite prevents subsurface flow to the east. The floor of Ball Diamond Meadow, even in autumn, has much standing water, and a rank growth of rushes and water grasses indicates the presence of water close to land surface throughout the meadow.

<u>Quality of Water</u>

The quality of water yielded by cased wells in residuum is generally good to excellent. However, shallow drilled wells, dug wells, and the spring at Dora Belle Campground are generally poor. The water from these sources has a strong objectionable taste and some waters contain finely divided organic matter. Furthermore, because the only method of disposal of sewage at the town of Shaver Lake is by septic tanks, chlorination has been resorted to in some supplies to eliminate bacterial contamination. A test of the campground water supply from spring 9/24-25N1 in May 1957 indicated 5 MPN per milliliter of pathogenic bacteria. Therefore, campers were advised to boil the spring water for human consumption.

No chemical analyses of ground waters at Shaver Lake were available to the writer; therefore, the source of the objectionable taste of the shallow waters is not explained. The association of shallow drilled and dug wells and presence of recognizable organic matter in some of the foul-tasting water suggests that organic compounds derived from decaying vegetation may be the source. Iron in solution may also be a contributing factor; however, no obvious iron staining around faucets or wash basins was noted.

Possibilities of Additional Water Supply

At first glance, a surface supply from Shaver Lake might appear to be the obvious solution to the water problem at Dora Belle Campground. This is impracticable, however, because (1) all available water is owned by the Southern California Edison Co. and needed for power generation and (2) owing to extreme fluctuations in the level of the lake, a pipeline, in order to provide an assured supply, would have to extend far out into the lake, at a prohibitive cost.

Possibilities of additional ground-water supplies may be divided into the three principal rock types: fresh granodiorite, talus, and residuum. Residuum is the chief source of water at the village; it provides fairly large supplies to wells that tap a thick section above fresh rock. Talus has not been developed extensively at Shaver Lake as a source of water, although the springs at Ball Diamond Meadow indicate the presence of moderate quantities of water. The fresh granodiorite has not been explored as a source of water locally, although locally in other parts of California inbored wells drilled in similar rocks have been successful in obtaining supplies for domestic use.

The most important aims in developing a new water supply for Dora Belle Campground are as follows: (1) yield should be sufficient to meet peak demand throughout the summer high-use period, (2) supply should have adequate reserve to allow for future expansion of camping facilities, (3) water should be chemically pure and biologically safe and preferably should not be subject to future pollution, and (4) the cost of development should not be excessive. Although the first three aims are important, the fourth, as in most water developments, is likely to be the governing factor. Methods available to augment the supply include development of springs, vertical wells, lateral wells, collection galleries, and subsurface drains.

Although the writer recognizes the difficulty of predicting relative success in an unprospected area, the several possibilities of increasing the present supply are discussed herafter in rough order of likelihood of success.

The most promising area for long-range development is in the talus at the foot of Mount Stevenson to the west of Ball Diamond Meadow. The catchment area for recharge is large, and the water is retained in the rock long enough to insure a late-summer supply. At the present time, there are no dwellings upslope to intercept or contaminate the ground water. Furthermore, the slope of the mountain is relatively free of decaying vegetation; hence, the chances of objectionable organic matter in the water are less.

It is likely that hard granodiorite lies at fairly shallow depths; therefore, vertical wells do not appear promising as a method of developing the ground water. A system that employs lateral holes or tunnels driven in the direction of the slope horizontally or with a slight grade is more likely to be successful. Still another method would be a subsurface dam to intercept ground water and direct it to a collecting point, if it could be bottomed on impervious rock so as to prevent underflow.

Ball Diamond Meadow receives a liberal supply of water throughout the year, and springs at the lower end are perennial, indicating that the ground-water basin of the meadow is full and overflowing. Under these conditions, a subsurface drain laid in a trench and backfilled with suitable permeable material might supply sufficient water for campground needs. Such a method would have an added advantage in that the system could be extended at slight cost as demand grows. A major disadvantage is that the floor of the meadow is a mass of decaying organic matter; accordingly, water of poor quality might be obtained. Vertical wells do not appear promising because of the possibility of penetrating encountering hard rock at shallow depth; although any well drilled would be virtually assured of a stable yield at a low lift, but the yield per well probably would be small, owing to the probable thinness and low permeability of the deposits.

Closer to the present campground, water in limited quantity probably could be obtained from wells drilled in residuum on the ridge due west of the campground, near the southwest corner of sec. 25. However, the residuum appears to be thin in this locality, and homes farther up the slope are in a position both to intercept the supply, and to form are a possible source of contamination. Moreover, the catchment area of this ridge is small and the slope is steep; therefore, it is doubtful that any ground water developed on the ridge would provide an undiminished late-summer supply.

Lateral holes drilled in granodiorite offer some promise of success. Because of the vertical jointing in the granodiorite, vertical wells are especially unpromising; lateral wells are far more likely to penetrate water-bearing joints. Any lateral holes should be drilled approximately S.70° W, so as to intersect the maximum number of master joints, which trend about N.20° W. Owing to the wide spacing of the joints in the granodiorite in the immediate vicinity of the present campground, that area does not appear to be a productive source of supply. More favorable sites are available in closely jointed rock near Ball Diamond Meadow. Locations generally west of the massive granodiorite outcrop that forms the east border of Ball Diamond Meadow appear to be suitable for a lateral or laterals drilled to intersect the master joints.

Well-numbering System

The well-numbering system used by the Geological Survey in California shows the locations of wells and springs according to the rectangular system for the subdivision of public lands. For example, in the number 9/24-35Q1, which was assigned to a well at Musick Creek Guard Station, the part of the number preceding the slash indicates the township (T. 9 S.); the number following the slash, the range (R. 24 E.); the digits following the hyphen, the section (sec. 35); and the letter following the section number, the 40-acre subdivision of the section as shown in the accompanying diagram.

D	C	B	A
E	F	G	H
M	L	K	J
N	P	Q	R

Within each 40-acre tract the wells are numbered serially, as indicated by the final digit of the well number.

References Cited

California State Water Resources Board, 1951, Water resources of California; Bull. 1, 648 p.

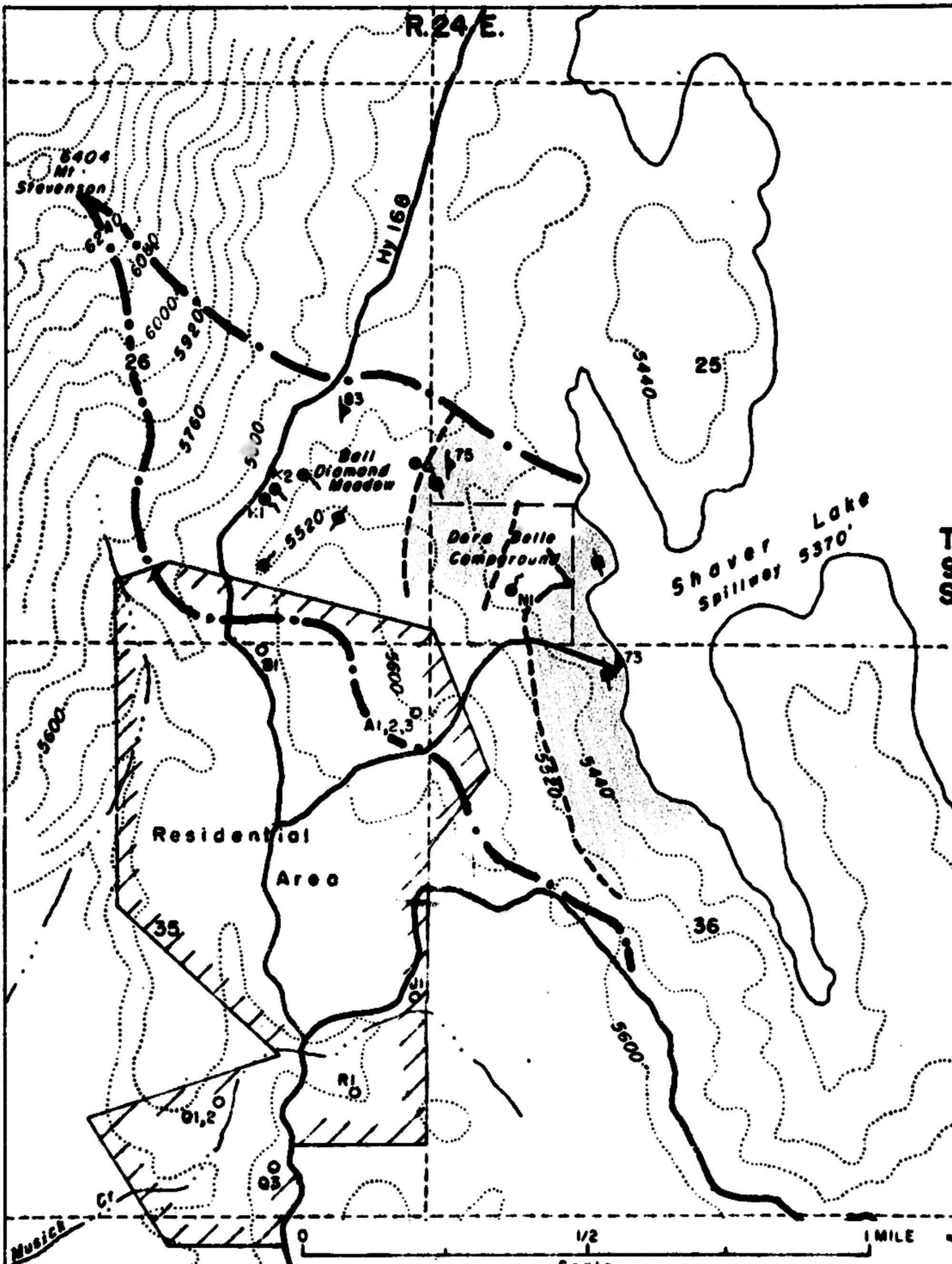
Krauskopf, Konrad B., 1953, Tungsten deposits of Madera, Fresno, and Tulare Counties, California; California Dept. Nat. Resources, Div. Mines Spec. Rept. 35, 83 p.

9-213-C
(March 1949)
Sketch Form

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
WATER RESOURCES DIVISION

File Figure 1

Sketch map of the vicinity of Shaver Lake, California (For explanation see attached sheet)



Sheet No. 1 of 2 Sheets. Prepared by G. Davis Date 10-31-57 Checked by .... Date ....

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UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
WATER RESOURCES DIVISION

File ....

EXPLANATION

Massive granodiorite having widely spaced joints; poorly water bearing

N1
Well

K1
Spring

Drainage divide

85
Strike and dip of foliation

Strike of vertical foliation

Strike of master vertical joints

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Table 1.--Descriptions of selected wells and springs in the Shaver Lake area, Fresno County, California.

Wells

Well no.	Owner	Year completed	Depth (feet)	Type and Casing Diam. (in.)	Type pump	Use	Depth to water below land surface (feet)	Temp. F°	Remarks
9/24-35A1	D. Young	1956	50	Drld. 8	1/2 in. jet	Unused	13.8		Quality excellent, csg. perforated 12-20 ft., hole uncased in hard rock below 20 ft. Production est. by owner at 90 gph.
-35A2	D. Young	1956	38	Drld. 12	1/2 hp jet	Dom.	14		Quality excellent. Owner estimates combined peak production of wells 35A2 and 35A3 at 3,000 gph. total.
-35A3	D. Young	1956	38	Drld. 12		Unused	19.5		You state that it is unused at the moment, yes?
-35E1	C. Eckert		42	Drld. 14		Dom.		48	Slight objectionable taste. Supplies restaurant, hotel, and cabins. Bottomed in hard rock.
-35J1	C. Mayers, Musick Meadows Tract	1950	65	Drld. 10	Cent.	Pub. Supply	5 rept.		Quality excellent. Cased to 32 ft., open hole to 65 feet. Pumps 1,140 gph at 20 ft. drawdown.
-35Q1	U. S. For. Ser. Guard Sta. well		19	Dug 5 ft. pipe	Cent. 1/2 hp	Dom.	7		Quality poor; fine organic matter present, ~~strong~~ objectionable taste. Supplies water to 12 persons. Casing pumps dry in about 30 min.
-35Q2	Musick Creek Tract coop.		20	Drld. 14		Pub. Supply			Quality poor, ~~strong~~ objectionable taste. Well breaks suction in 4 min., recovers in 15 min. Used to supplement supply from well 35Q3.
-35Q3	Musick Creek Tract Coop.	1950	29	Dug 5 ft. Con. pipe		Pub. supply		47	Quality fair, ~~strong~~ objectionable taste. Supplies water to 35 homes. Adequate except in late summer.
-35R1	C. Mayers	1955	76	Drld. 10	Cent. 2 hp	Pub. supply	14+		Quality excellent. Casing perforated 61-76 ft. Solid rock at 64 ft. Most water believed to come from 61-64 ft. Supplies 75 connections. Pumps 1,080 gph.

Very little information is conveyed by the word; a more descriptive term should be used, - earthy, moldy, swampy, mineral, sulfur, iron, offensive!

FHL

Table 1.- Continued.

Springs

Location no.	Owner	Year developed	Description of opening	Yield	Use	Temp. F°	Remarks
9/24-26K1	So. Calif. Edison Co.	Circa 1910	Timber cribbing 6.6 x 8 ft. square.	No surface discharge.	Unused	48	Formerly supplied sawmill at site. Pumped down 5 ft. in 2 hrs. Recovered at initial rate of 75 gph, average rate of 50 gph over 5½ hour period.
-26K2	So. Calif. Edison Co.	Circa 1910	Timber cribbing 8 x 8 ft. square	No surface discharge.	Unused		Formerly supplied sawmill at site. 170 ft. NE of spring 26K1.
-25M1	U. S. For. Ser.	1928	Concrete lined hole 3 ft. deep	100 gph	Public supply	50	Dora Belle Campground supply. Spring discharges to 1,500 gallon tank through 1½ in. line. Flow declines in late summer. Inadequate to meet demand. Quality poor, objectionable taste, must be boiled for domestic use.